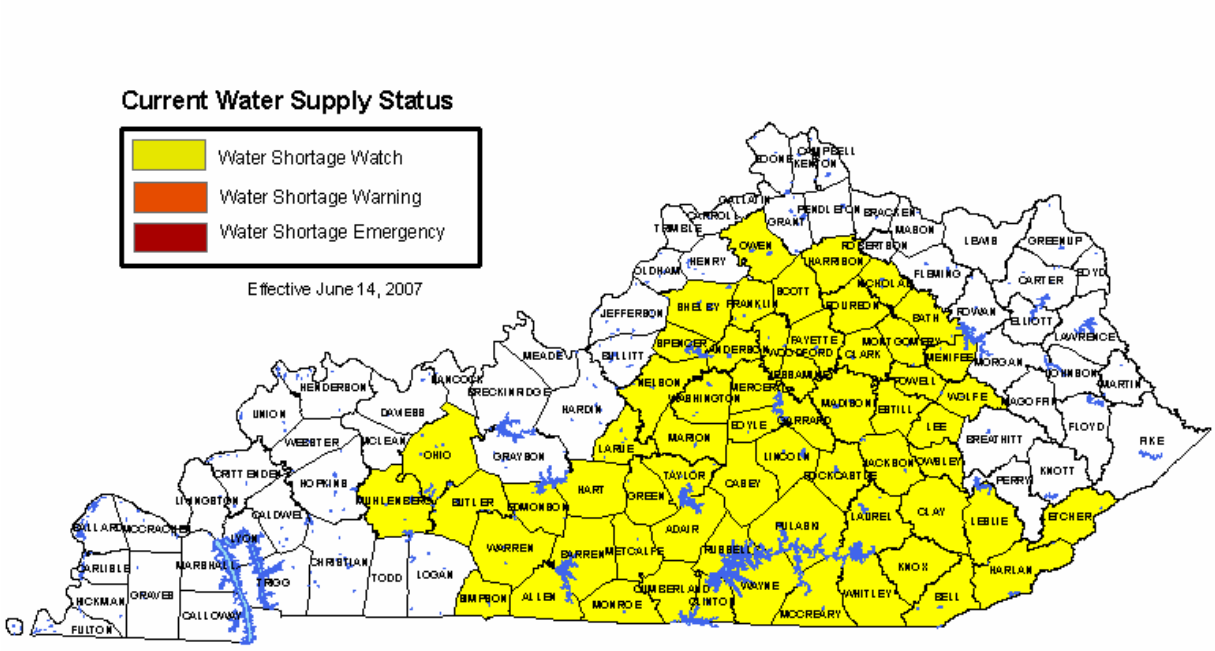
Drought

The Kentucky Division of Water continuously monitors hydrologic conditions throughout the state, including precipitation, streamflows, lake elevations and various drought indices. This information is used to detect emerging drought conditions, to identify the locations and severity of drought and to provide timely and appropriate public notification.

Kentucky Drought Monitoring Center



[Water Shortage Notification System Explained]

Statewide Summary of Drought Development

Updated July 26, 2007

Drought conditions across Kentucky have steadily improved thanks to a July that has provided weekly precipitation mostly in the form of scattered showers and thunderstorms. Significant relief did finally arrive on July 20 as widespread and beneficial storms brought 1 to 3 inches of rainfall to a majority of the state. Most drought indicators show signs of improvement to the long-term drought conditions that have persisted since the middle of May. There is still a relatively large accumulated deficit of precipitation in all four climatic divisions that will require several inches of above normal rainfall to erase. However, a continuation of near-normal rainfall can sustain acceptable levels of streamflows for water supplies and eliminate serious impacts of surface drought to crops, pastures, and urban landscapes.

Useful Drought Indicators

PRECIPITATION

Kentucky's short-term precipitation status continues to improve. Normal summertime weather patterns in July have moved the 30-day rainfall averages of the Western, Central and Bluegrass climatic divisions into a normal range for this time of year. Most areas of the Eastern climatic division have seen significant improvement in the past 30 days as well, but still remain below normal for this time of year.

STREAMFLOWS

For the past four weeks streamflows have varied between low to severely low in most areas of the state. Scattered precipitation events during this time have served to stabilize flows and prevent critical low flow conditions from developing in many areas. Current observations indicate near-normal to normal flows for this time of year in most of the Big Sandy, Little Sandy and Tygarts river basins in eastern Kentucky. Out west, flows in the Purchase area of Kentucky are at normal levels for this time of year as well. Streamflows in the headwaters of the Kentucky River basin jumped substantially this week with above normal flows currently observed in the North, Middle and South forks of the basin. Expect flows in the mainstem of the Kentucky River below Beattyville will improve over the next few days as the water makes its way downstream. The Upper Cumberland river above Lake Cumberland is currently above normal as measured by the streamflow gauge at Williamsburg. Elsewhere, flows in the Green, Lower Cumberland, Salt and Mississippi/Tennessee river basins are holding at levels slightly below to below normal for this time of year.

LAKE ELEVATIONS

Most small water-supply lakes are not heavily impacted at this time. Lakes under the control of the Huntington District, Louisville District and Nashville District of the U.S. Army Corps of Engineers continue to operate along their normal lake elevation curves. Two exceptions are the Barren River Reservoir in Barren County and Rough

River reservoir in Breckinridge County. Barren River reservoir is having difficulty bringing the elevation to normal pool and is currently down by 4.4 feet. Discharges from the dam have been at or near the minimum release most of the time since March 20, 2007. Similarly, Rough River reservoir is 0.9 feet below normal pool and has been at or near to minimum release since March 16, 2007. Releases from Corps of Engineers reservoirs are important to the status of many Kentucky rivers as sources of supply for drinking water, assimilation of wastewater discharges, water quality and aquatic habitat. These rivers include the Green, Barren, Rough, Nolin, Kentucky, Salt, Licking and Big Sandy rivers.

DROUGHT INDICES

Assessing the severity of a drought is made easier with the use of drought indices that combine various source information into a single representative value of drought severity. The Palmer Drought Severity Index uses data for precipitation, temperature and evapotranspiration (the water returned to the atmosphere through the combined actions of evaporation and plant growth) to calculate a number that can be compared across different times and locations. This index was developed in the 1960's in Kansas and Nebraska but has since become a part of drought monitoring in a majority of the United States. The Palmer Drought Severity Index is updated weekly on Monday afternoons.

The Palmer Drought Severity Index issued on July 23, 2007, places the Western, Bluegrass and Central climatic divisions in moderate drought status with the Eastern climatic division remaining at moderate drought status.

A second and more recent drought index is the Climate Prediction Center's Drought Monitor. The Drought Monitor represents a comprehensive assessment of several factors that contribute to the development of drought or that indicate the severity and potential persistence of drought. The Drought Monitor is updated weekly on Thursday mornings.

The most recent Drought Monitor has not changed from last week. Mild to moderate drought is indicated west and north of a line from Kenton to Boyle to Christian counties. To the east of this line severe drought remains, with a small pocket of extreme drought in southeast Kentucky centered around Bell, Knox and Whitley counties. However, three-fourths of an inch of rainfall that fell in areas of southeast Kentucky on July 25, too late to be a factor in the latest edition of the Monitor.

As a drought indicator, the Drought Monitor is not limited to four large climatic divisions, rather it incorporates the Palmer Index as just one of several indicators of drought development in a given area. These other indicators include more short-term components including the Crop Moisture Index, Standardized Precipitation Index and weekly streamflow percentiles. The Palmer Drought Severity Index and the Drought Monitor should be considered in combination with more localized data such as rainfall, streamflows, groundwater levels and climatic outlooks to form an accurate assessment of drought severity in a given location.

Drought Monitoring

Drought is a natural and recurring feature of our climate that can be considered a "severe" weather event much like a tornado, a flood or a hurricane. However, there are a few key differences that distinguish drought from other weather events that make it difficult to detect, track and respond to drought.

Part of the difficulty in detecting drought is in the lack of an obvious onset of drought conditions. A drought develops slowly and can appear to mimic a normal spell of dry weather in the summer, a time of the year when dry weather is accepted and expected. Short-term rainfall shortages create problems for agricultural crops, livestock, urban landscapes and other activities that depend on stored soil moisture between rainfall events. We are accustomed to dealing with short-term dry spells in part because there is an expectation that rainfall is just around the corner. However, when rainfall shortages persist for weeks or months at a time, activities that depend on long-term storage of water will be adversely impacted as well. Droughts in Kentucky can have serious negative consequences for drinking water supplies, energy production, commercial and industrial operations, recreation and aquatic habitat.

The negative impacts of drought cannot be avoided but there are ways to reduce them to a manageable level. All water suppliers in the commonwealth should have a water shortage response plan to guide both the supplier and customer during a drought event. It is important for customers to listen to their water suppliers and be ready to take necessary actions to prevent a water shortage problem from developing. This is critical to a successful outcome because the only way to effectively manage the source of water supply is to first manage the demand for water.

There is no easy method for determining when a dry spell has become a drought, how long a drought will persist or how intense a drought may become. However, by closely tracking certain sources of information, referred to as drought indicators, it is possible to detect potential drought development early enough to allow at least some lead-time for notification and initiation of drought response preparations at the local level. The Division of Water monitors for the potential development of drought in Kentucky by tracking precipitation, streamflows, lake levels, groundwater and water supplies. There are also several tools that are useful in assessing the severity of a "dry spell" and the potential impacts to agriculture, forest fires, water supplies and other vulnerabilities to drought. These tools include the Palmer Drought Severity Index, the Drought Monitor, the Standardized Precipitation Index and several others.

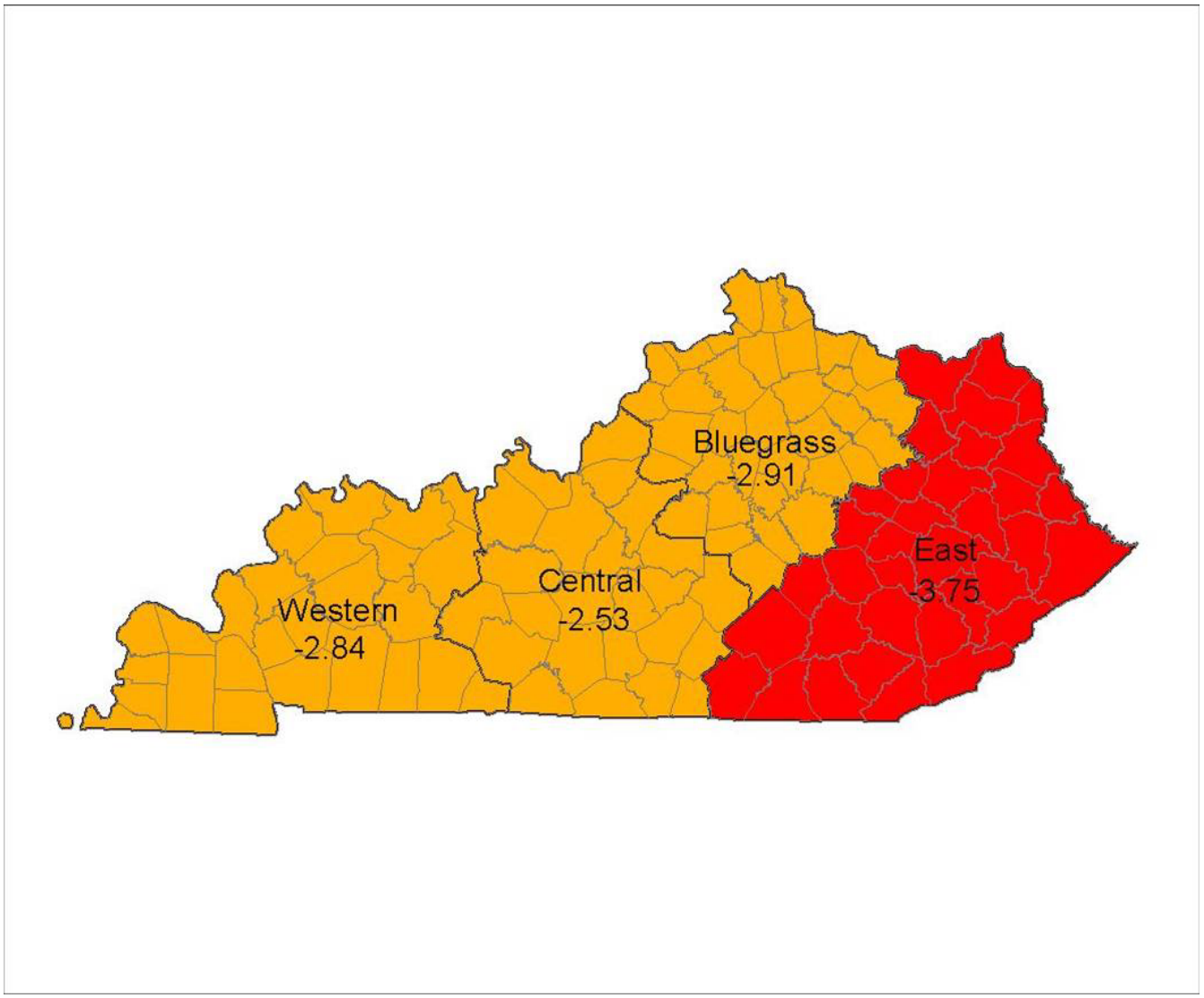
The Drought Monitoring pages will be updated on a weekly basis to provide timely information and assessments of current drought conditions in Kentucky. There will also be numerous links to other resources and drought information pages from various state and federal agencies.

Updated July 26, 2007

Palmer Drought Severity Index The Palmer Drought Severity Index (PDSI) is compiled weekly by the Central Region Climate Prediction Center (National Centers for Environmental Prediction, National Weather Service and National Oceanic and

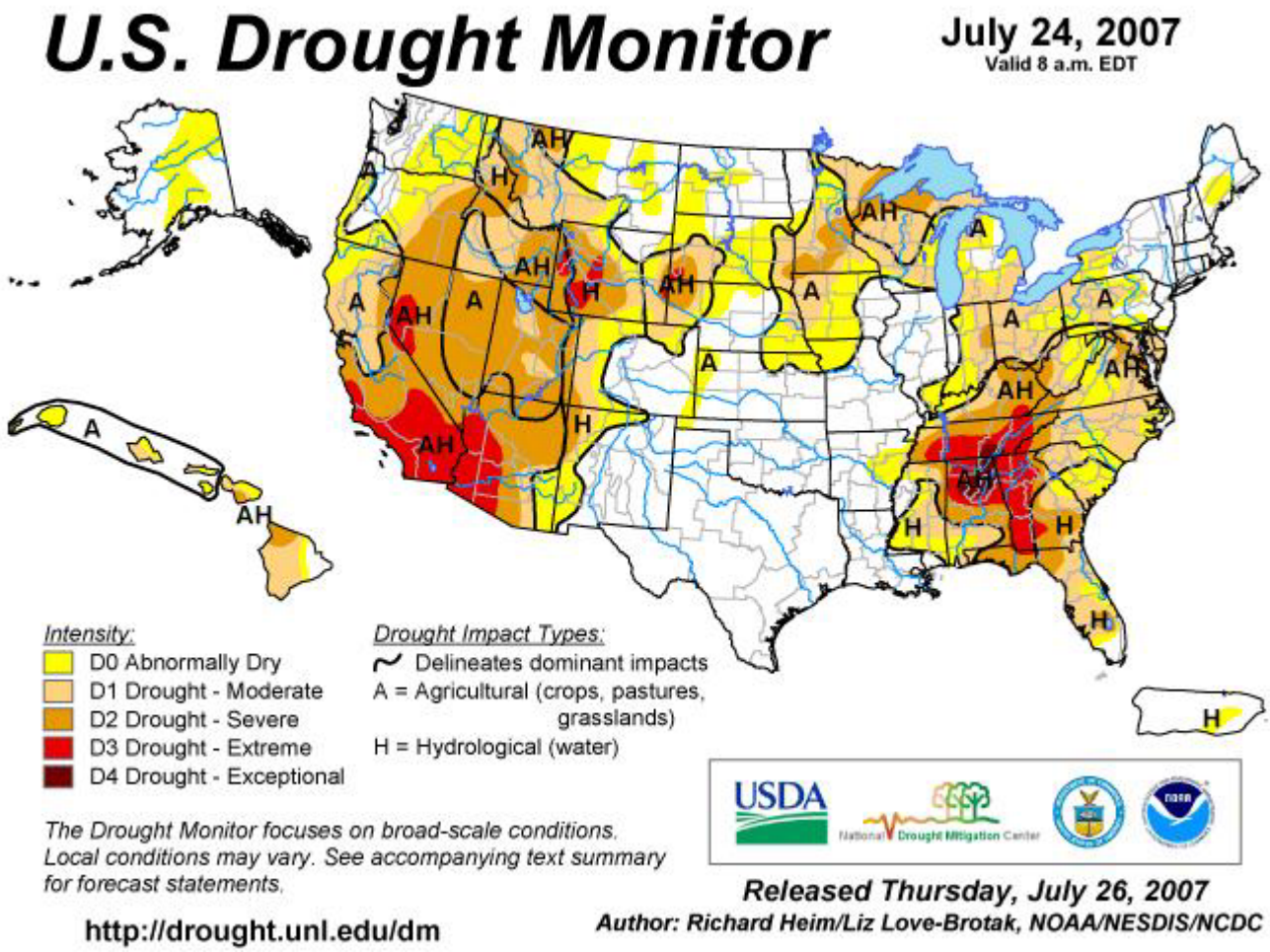
Atmosphere Administration) and provided on the University of Kentucky Agricultural Weather Center's Web site. This index is useful for placing a developing drought into context with past droughts and serves as a measure of current conditions. The index also provides a standardized assessment of developing drought conditions that can be compared between different areas of the state or even between different states.

PDSI values can be categorized as follows:



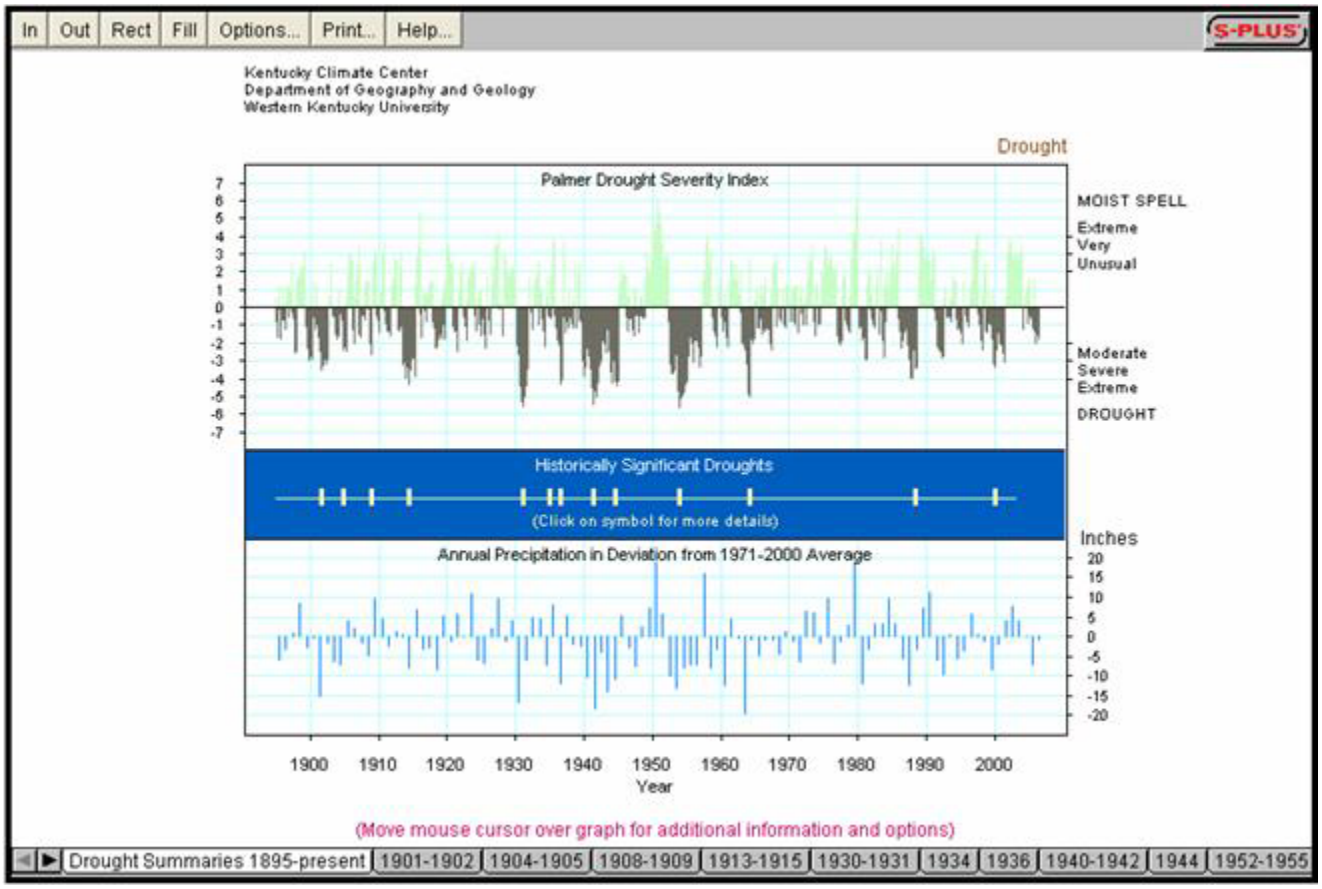
- 0 to -0.99 = near normal
- -1.00 to -1.99 = mild drought
- -2.00 to -2.99 = moderate drought
- -3.00 to -3.99 = severe drought
- -4.00 and below = extreme drought

The Drought Monitor



Tracking drought blends science and art. No single definition of drought works for all circumstances, so people rely on drought indices to detect and measure droughts. But no single index works under all circumstances, either. The Drought Monitor is a synthesis of multiple indices, outlooks and news accounts, that represents a consensus of federal and academic scientists. A detailed description of the parameters used to create the Drought Monitor can be found here.

Kentucky Climate Center Historical Drought Data



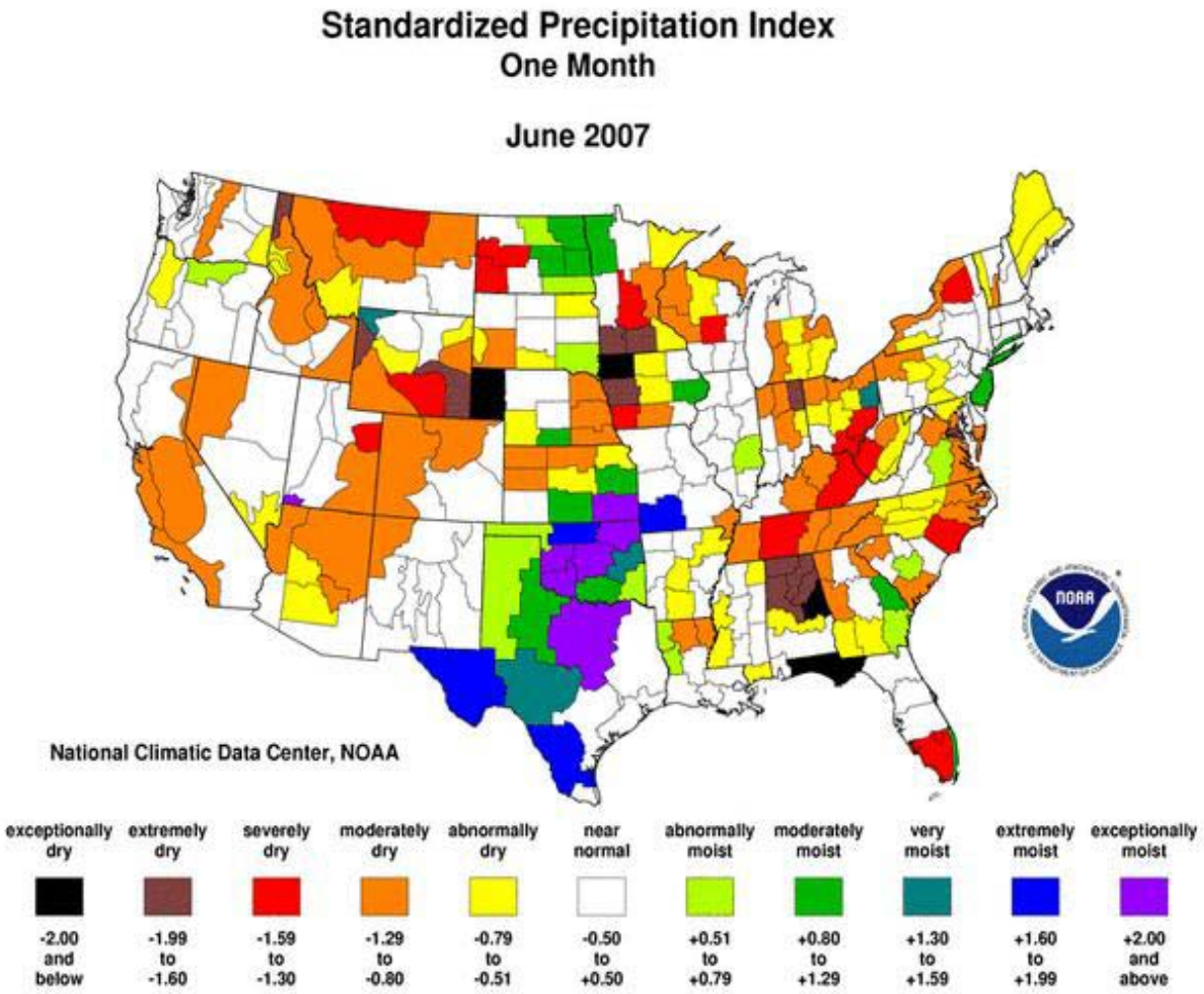
Interactive graphs displaying drought indices since 1895 for Kentucky's four climate divisions. Users can identify and explore the development of historically significant droughts.

Examining the past can be a useful tool in interpreting the significance of a developing drought situation. Comparisons of the current drought to the historical record provide a frame of reference for evaluating how serious the current drought has become, and how it might develop in the coming months. One of the best tools to evaluate past droughts is found at the Kentucky Climate Center at Western Kentucky University. Click on the figure at the left to visit this site and learn more about the history of drought in Kentucky.

The Standardized Precipitation Index

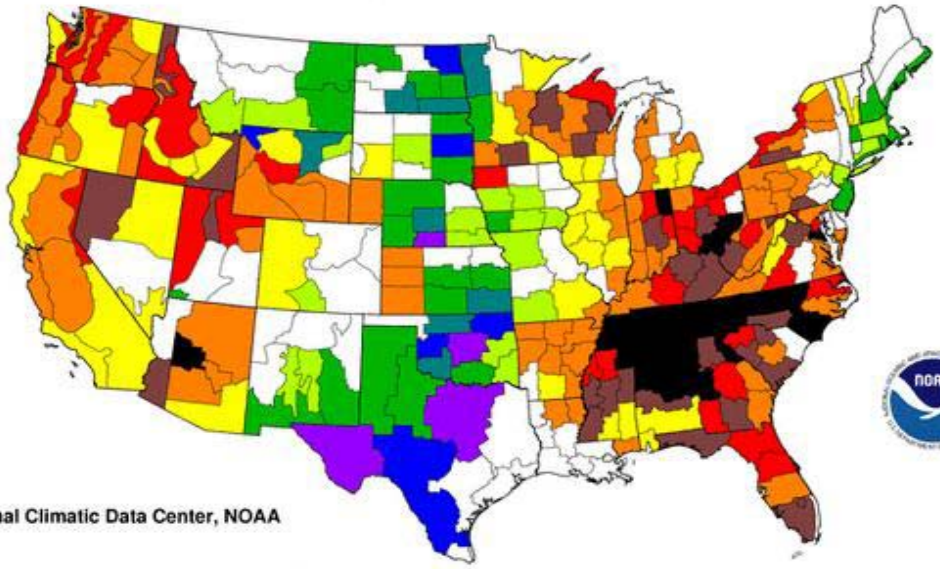
The Standardized Precipitation Index (SPI) is a way of measuring drought that is different from the PDSI. Like the PDSI, this index is negative for drought and positive for wet conditions. But the SPI is a probability index that considers only precipitation,

while Palmer's indices are water balance indices that consider water supply (precipitation), demand (evapotranspiration) and loss (runoff).



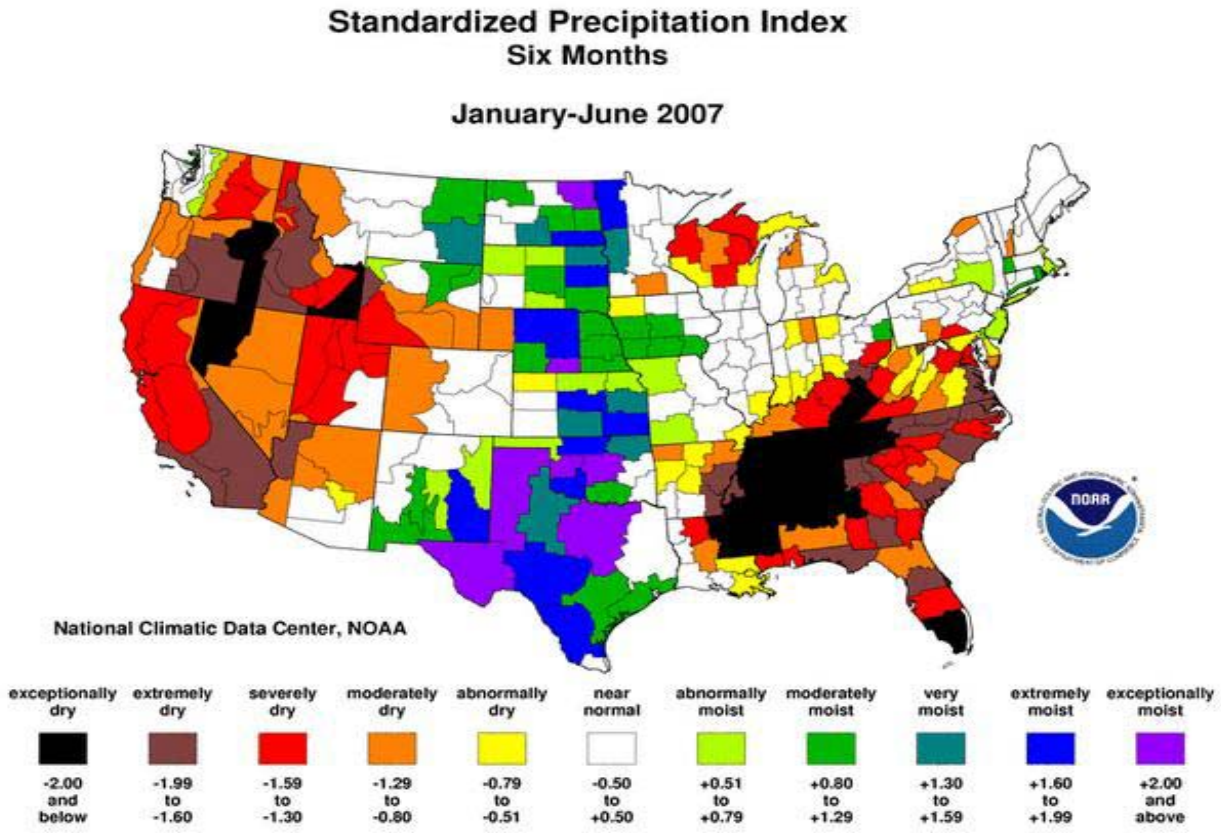
Standardized Precipitation Index
Three Months

April-June 2007

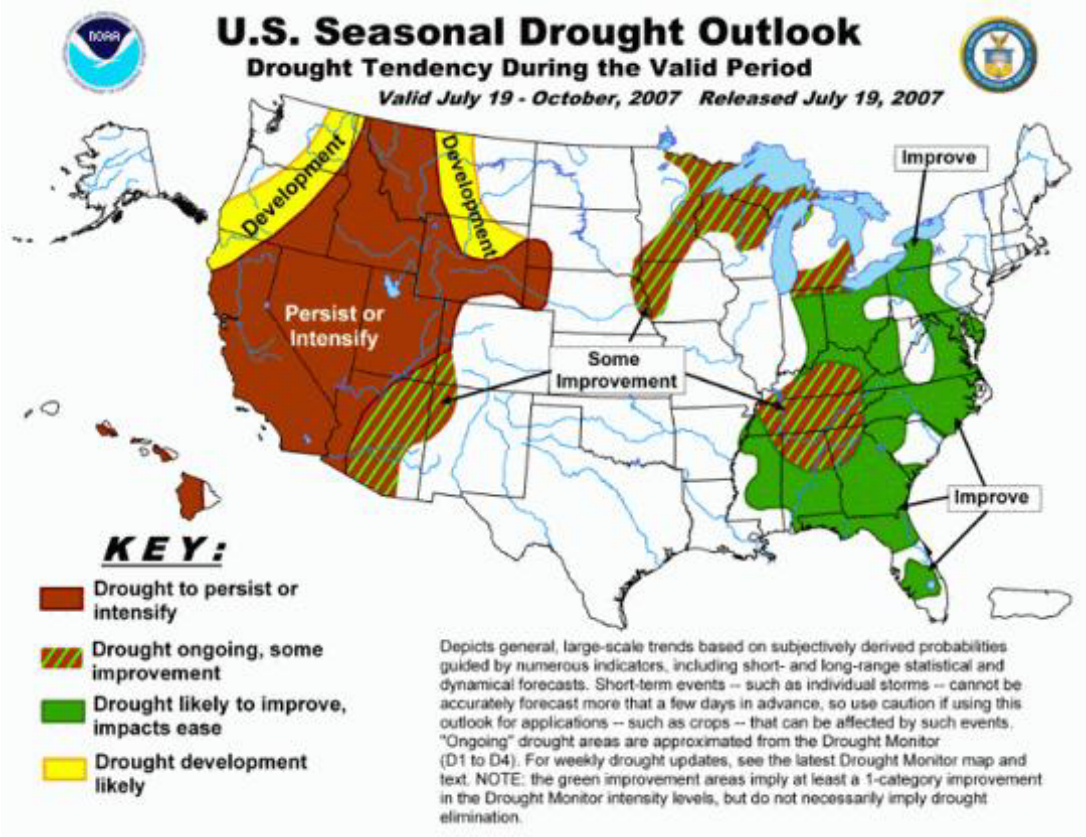


National Climatic Data Center, NOAA

exceptionally dry	extremely dry	severely dry	moderately dry	abnormally dry	near normal	abnormally moist	moderately moist	very moist	extremely moist	exceptionally moist
-2.00 and below	-1.99 to -1.60	-1.59 to -1.30	-1.29 to -0.80	-0.79 to -0.51	-0.50 to +0.50	+0.51 to +0.79	+0.80 to +1.29	+1.30 to +1.59	+1.60 to +1.99	+2.00 and above



U.S. Seasonal Drought Outlook



The Climate Predication Center issues the U.S. Seasonal Drought Outlook each month in conjunction with the release of the long-lead temperature and precipitation outlooks.

Weather and Climate

PRECIPITATION

Updated July 26, 2007

(Click on images to enlarge)

Precipitation: Data for the previous 30/60/90-day period and the Water Year Beginning October 01, 2006

	Water Year		30/60/90 Day Total Precipitation and Departure From Normal					
Station	Precipitation Totals (inches)	Departure From Normal (inches)	30 Day Total (inches)	30 Day Departure (inches)	60 Day Total (inches)	60 Day Departure (inches)	90 Day Total (inches)	90 Day Departure (inches)
Henderson	32.27	1.35	1.29	-3.28	5.88	-2.85	9.26	-4.06
Paducah	33.68	-1.04	2.32	-2.63	5.75	-4.04	8.72	-5.87
Princeton	30.11	-6.18	2.05	-2.88	5.96	-3.64	8.32	-6.07
Mayfield	27.58	-10.52	0.60	-4.16	3.85	-5.93	5.75	-9.21
Louisville	30.34	0.04	1.19	-3.26	6.33	-2.39	9.31	-3.87
Bardstown	27.05	-2.41	0.61	-3.84	5.24	-3.16	8.62	-3.98
Hardinsburg	29.47	-4.05	1.24	-3.48	5.51	-3.58	7.82	-5.70
Campbellsville	29.07	-6.24	1.69	-3.51	7.53	-2.45	11.86	-2.88
Nolin Lake	30.33	-5.12	3.35	-1.90	8.12	-1.79	10.49	-3.60
Glasgow	27.72	-8.33	1.38	-3.63	6.30	-3.32	9.49	-4.98
Bowling Green	25.25	-10.23	2.58	-2.26	6.60	-2.63	7.55	-6.52
Covington	24.60	-3.06	0.92	-3.31	3.46	-4.58	6.07	-6.02
Williamstown	32.10	2.93	1.80	-2.53	5.99	-2.51	12.43	-0.56
Spindletop	21.72	-7.66	1.30	-3.07	4.69	-3.63	7.17	-5.35
Lexington	26.89	-2.48	2.22	-2.14	5.96	-2.35	8.75	-3.76
Dix Dam	24.47	-6.36	1.26	-3.38	5.62	-3.30	9.45	-3.70
Berea	24.11	-6.60	1.49	-3.28	5.69	-3.41	9.30	-3.93
Grayson	24.78	-2.65	1.82	-2.06	5.34	-2.71	8.35	-3.19
Jackson	21.76	-9.63	1.88	-2.52	4.27	-4.27	5.67	-7.06
Quicksand	20.38	-11.12	1.87	-2.65	4.21	-4.45	5.60	-7.24
Buckhorn Lake	18.13	-12.27	0.63	-3.51	3.84	-4.09	6.00	-6.04
London	21.97	-9.18	0.96	-3.29	5.88	-2.32	6.66	-5.77
Somerset	26.75	-7.78	1.30	-3.80	5.31	-4.23	7.63	-6.30
Cumberland Gap	20.80	-14.40	0.30	-4.44	4.62	-4.30	7.75	-5.93

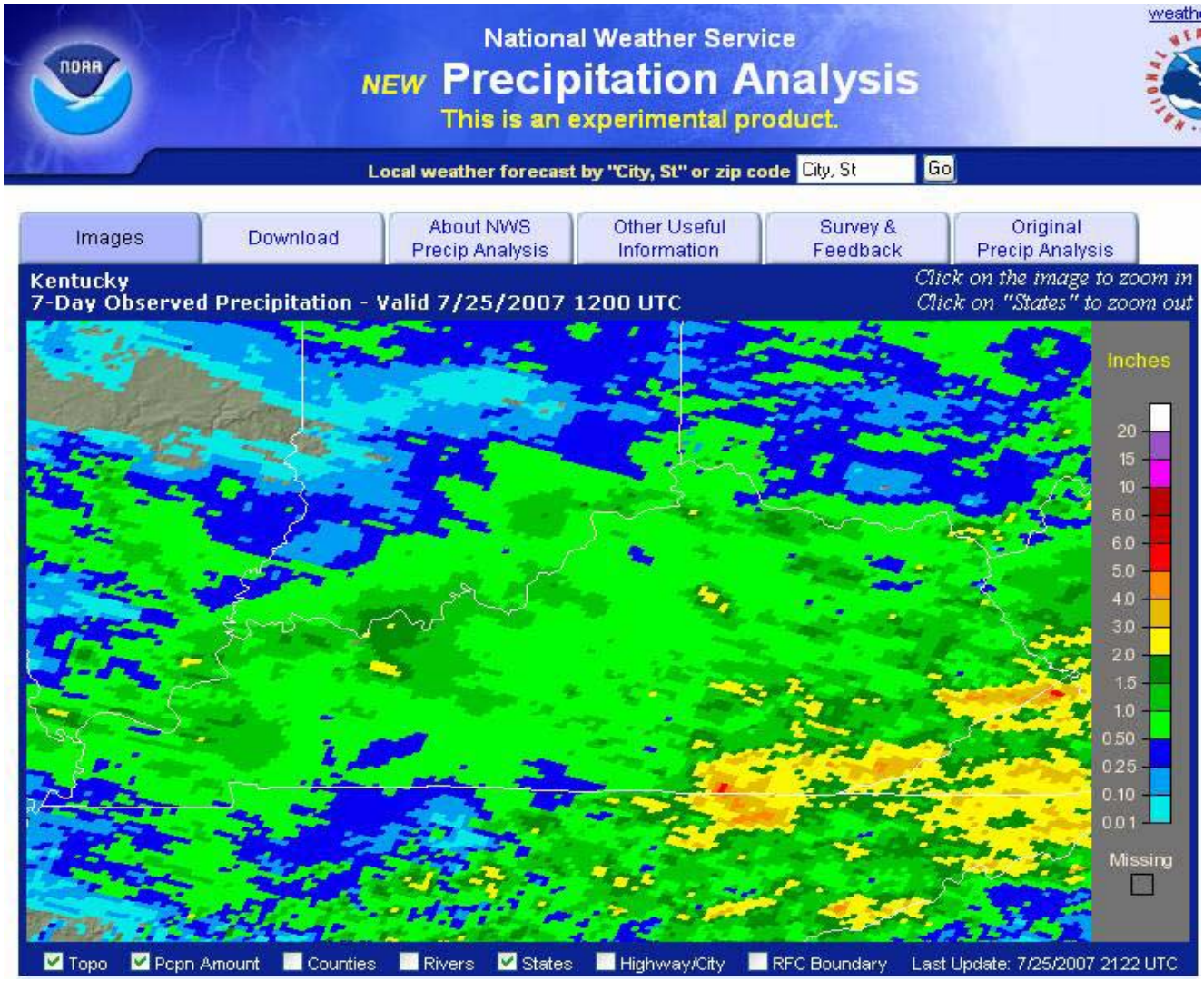
Climatic Division	Normal Precip. Water Year	Normal Precip. Calendar Year	Percent of Normal Precipitation				
			Water Year	Calendar Year	30 Day	60 Day	90 Day
Western (1)	41.30	29.05	88	75	111	72	64
Central (2)	40.61	28.96	86	80	122	74	77
Bluegrass (3)	36.11	26.00	84	79	97	69	64
Eastern (4)	38.62	27.61	68	62	72	54	54

The Division of Water monitors a network of 24 daily climate-reporting stations to track developing shortages of precipitation. For the year, precipitation deficits for range from 62 percent of normal in the Eastern climatic division to 79 percent of normal in the Central climatic division. A survey of individual climate stations in each climatic division shows a distinct south to north disparity in precipitation coverage.

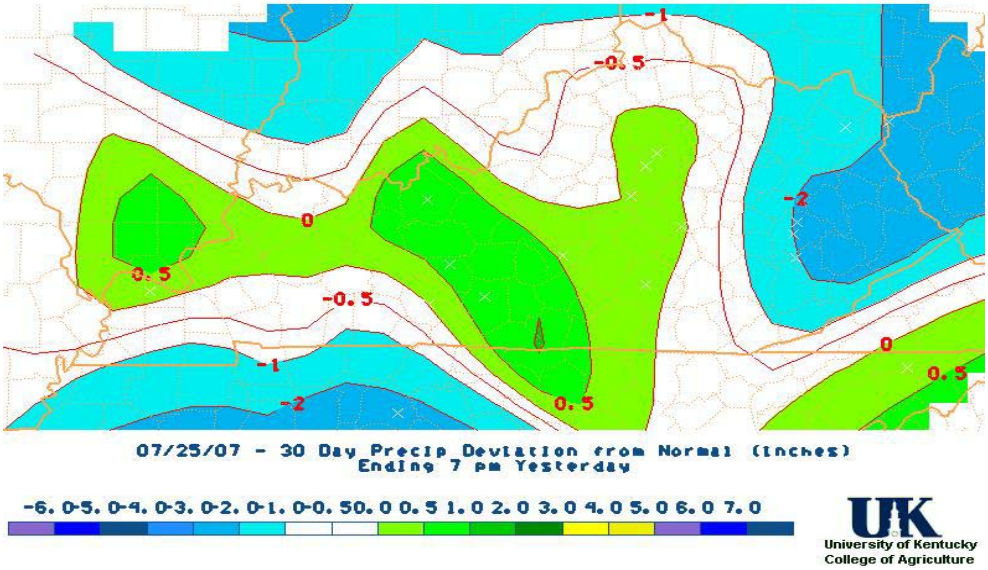
Variation in precipitation coverage within the four climatic divisions for the current year ending July 13, 2007.				
	South		North	
Climatic Division	Location	Percent of Normal	Location	Percent of Normal
Western	Mayfield	70	Henderson	100
Central	Bowling Green	69	Louisville	96
Bluegrass	Berea	78	Williamstown	104
Eastern	Buckhorn Lake	52	Grayson	83

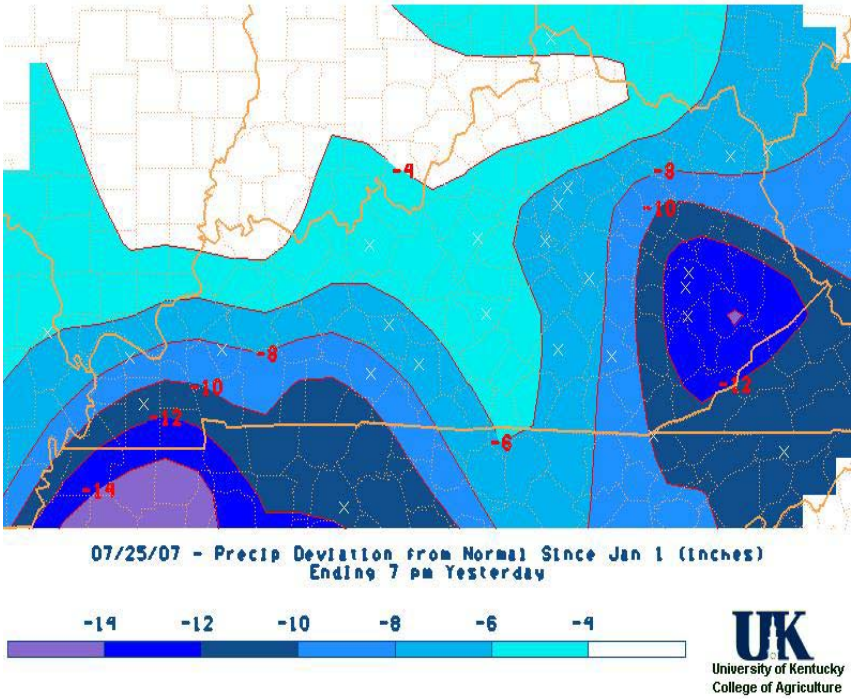
Kentucky's short-term precipitation status continues to improve. Normal summertime weather patterns in July have moved the 30-day rainfall averages of the Western, Central and Bluegrass climatic divisions into a normal range for this time of year. Most areas of the Eastern climatic division have seen significant improvement in the past 30 days as well, but still remain below normal for this time of year.

For the 30-day period ending July 25, 2007 average precipitation amounts of four to seven inches were measured across the Western, Central and Bluegrass climatic divisions. Lesser amounts, about 2 to 4 inches, were measured across the Eastern climatic division. Statewide, the combined precipitation for the months of January through June of this year ranked as the fourth driest for the period since at least 1895 -- the first year of the instrumental record. A recurrence of beneficial rains and somewhat cooler temperatures should continue to slow, and in some cases reverse, the rate of drought development.



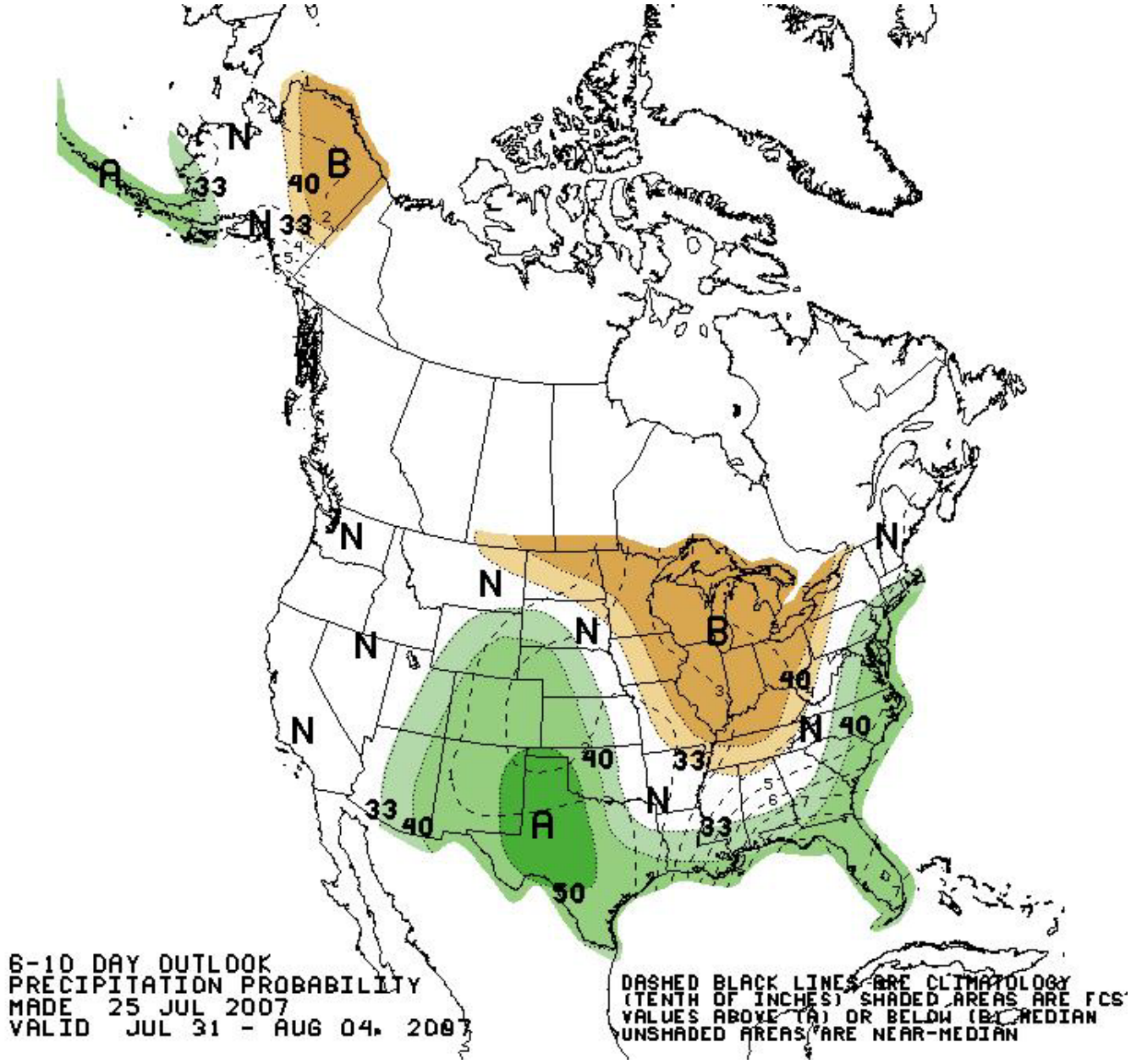
ATTENTION: One of the best tools to assess the amount and distribution of precipitation in Kentucky is the National Weather Service's Precipitation Analysis Product. Data can be displayed for many different time frames and can be selected to show not only the amounts, but also the deficits and percentages of normal for each time frame.

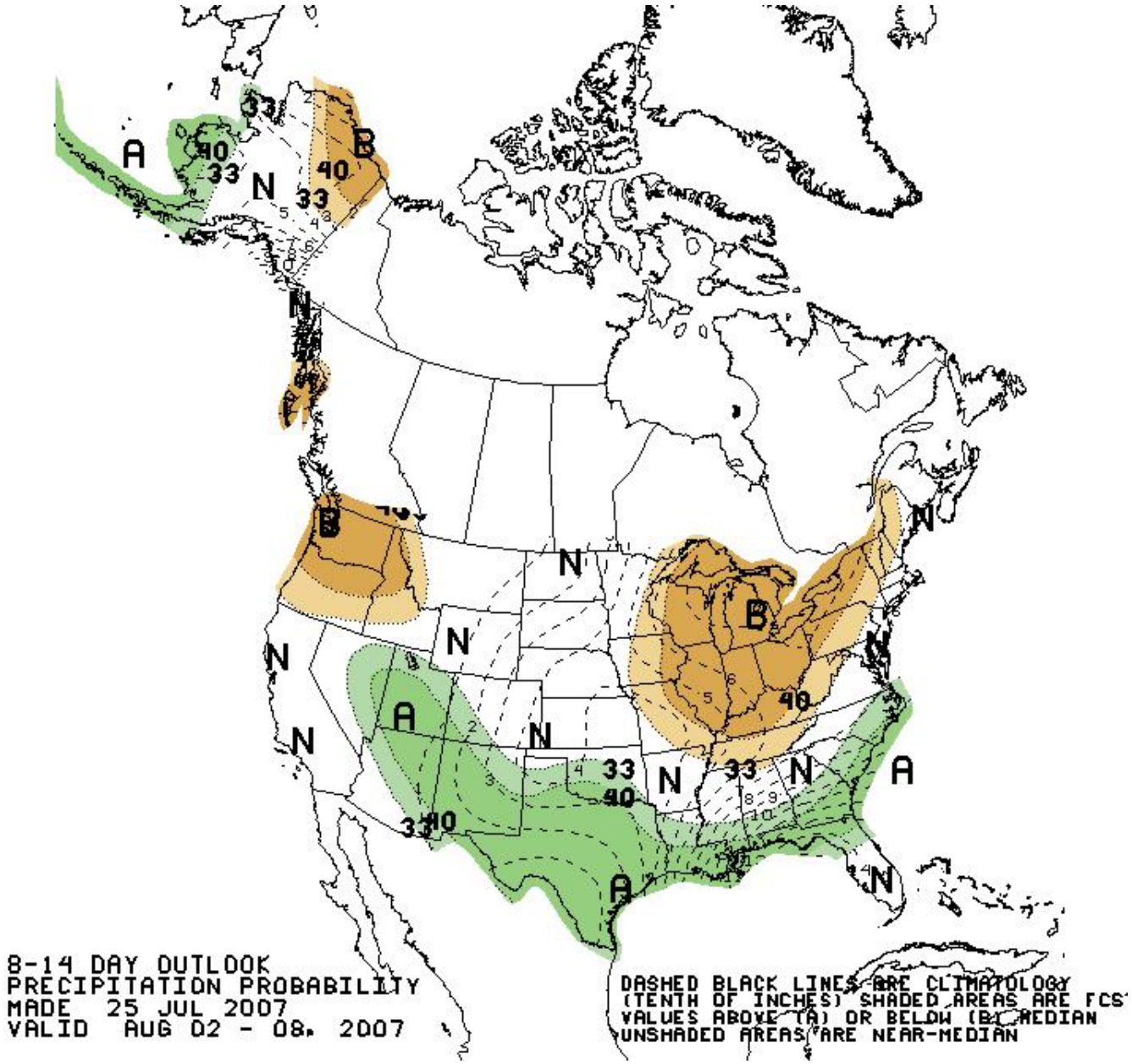




For the year, the largest deficits remain in the southern portions of the Western and Eastern climatic divisions. Eight to 12-inch deficits in precipitation persist in parts of the Purchase area of the west and the headwaters of the Kentucky, Licking, Cumberland and Big Sandy river basins in the east. Deficits up to 12 inches persist in an area centered around Knott, Breathitt, Perry and Letcher counties in headwater regions of the Kentucky and Licking river basins. Central and northern Kentucky

deficits range from 2 to 4 inches in the extreme north and 4 to 6 inches in the Bluegrass and parts of south-central Kentucky. The rains of July have been beneficial in reversing the effects of severe drought on crops, pastures and lawns. However, recurrent events with above normal rainfall is still needed to make a significant change to the deficit that has accumulated this year.





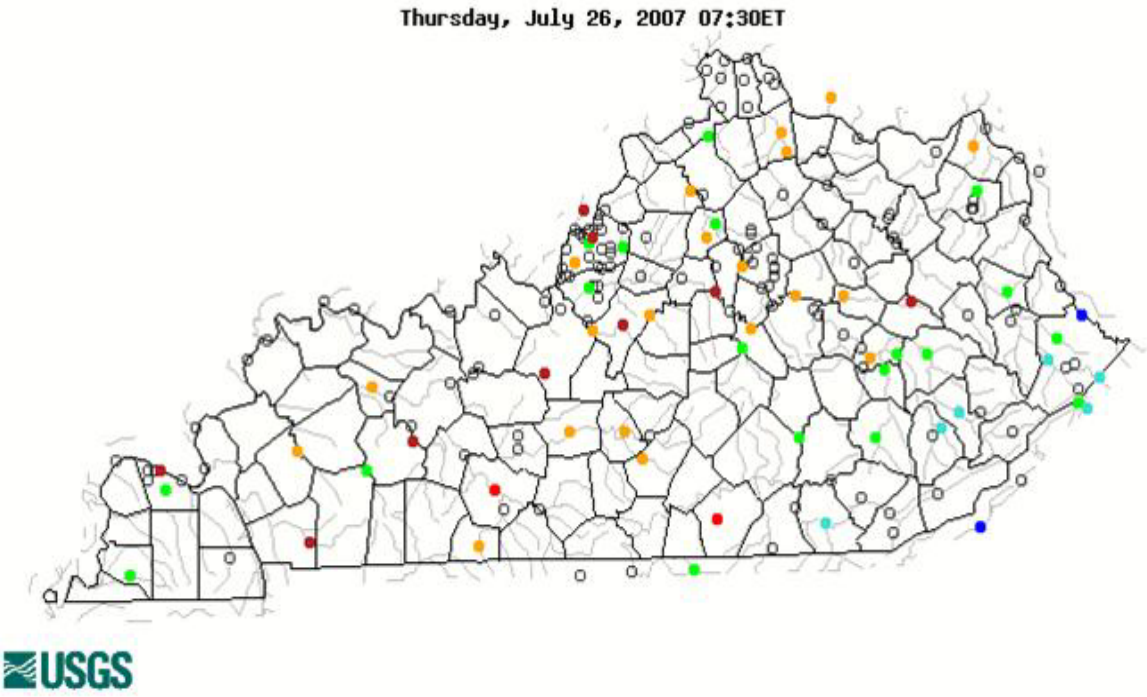
Short-term outlooks from the Climate Prediction Center indicate below normal chances for precipitation during the next two weeks. Deeper drought that impacts streamflows, groundwater levels, spring discharges and lake levels will remain, but as in past weeks, slight improvement can come in the form of scattered showers and thunderstorms that produce locally heavy events in some areas. Looking ahead, the outlooks for the next one to three months indicate equal chances for below normal,

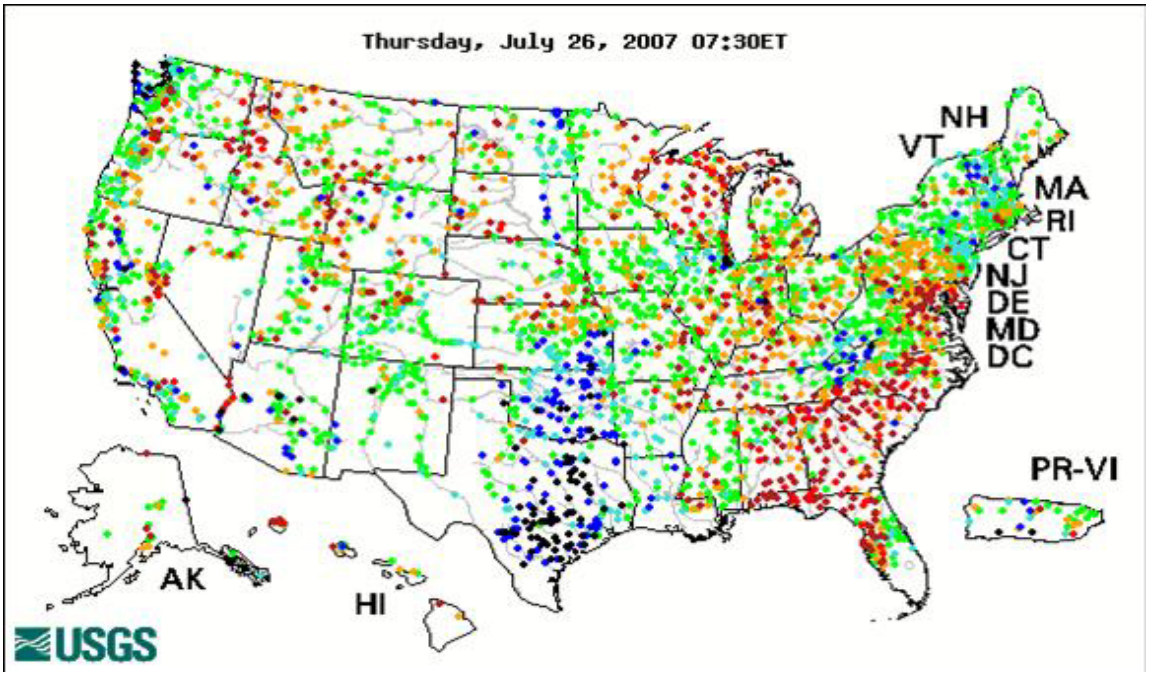
normal and above normal rainfall for the state. Given the rainfall deficits that have developed with the first half of 2007, the probability of ending the drought within the next few months is quite small. However, typical summertime weather systems can provide enough rainfall to keep extreme drought at bay until more widespread relief comes our way.

Hydrology

STREAMFLOWS

Updated July 26, 2007





The U.S. Geological Survey maintains a real-time stream gauging network that monitors flows in all major river basins in Kentucky. Measurements of streamflow are a very good indicator of the longer-term hydrologic impacts of drought. During the developing stages of drought, streamflows provide valuable information on the severity and regional extent of emerging problems. Streamflow data is evaluated relative to the long-term record to determine drought intensity and identify potential problems associated with water shortages. Once a drought has matured, streamflow measurements are critical at many locations where water withdrawals have the potential to cause adverse environmental impacts to streams.

For the past four weeks, streamflows have varied between low to severely low in most areas of the state. Scattered precipitation events during this time have served to stabilize flows and prevent critical low flow conditions from developing in many areas. Current observations indicate near-normal to normal flows for this time of year in most of the Big Sandy, Little Sandy and Tygarts river basins in eastern Kentucky. Out west, flows in the Purchase area of Kentucky are at normal levels for this time of year as well. Streamflows in the headwaters of the Kentucky River basin jumped substantially this week with above normal flows currently observed in the North, Middle and South forks of the basin. Expect flows in the mainstem of the Kentucky River below Beattyville to improve over the next few days as the water makes its way downstream. The Upper Cumberland river above Lake Cumberland is currently above normal as measured by the streamflow gauge at Williamsburg. Elsewhere, flows in the Green, Lower Cumberland, Salt and Mississippi/Tennessee river basins are holding at levels slightly below to below normal for this time of year.

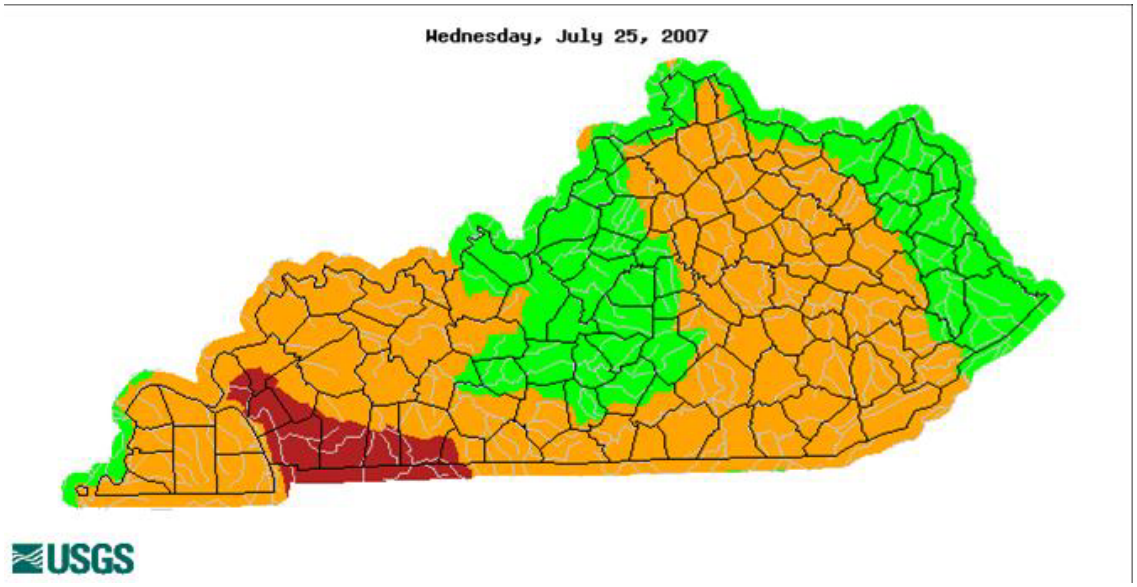
The climatic conditions (periods of cooler temperatures and modest rainfall) of the past 4 weeks have been sufficient to hold hydrologic drought development in check. While we have yet to see the kind of widespread, soaking rains that will be necessary to alleviate hydrologic drought, scattered but frequent rainfall events can produce enough runoff to help slow the recession of streamflows enough to delay the

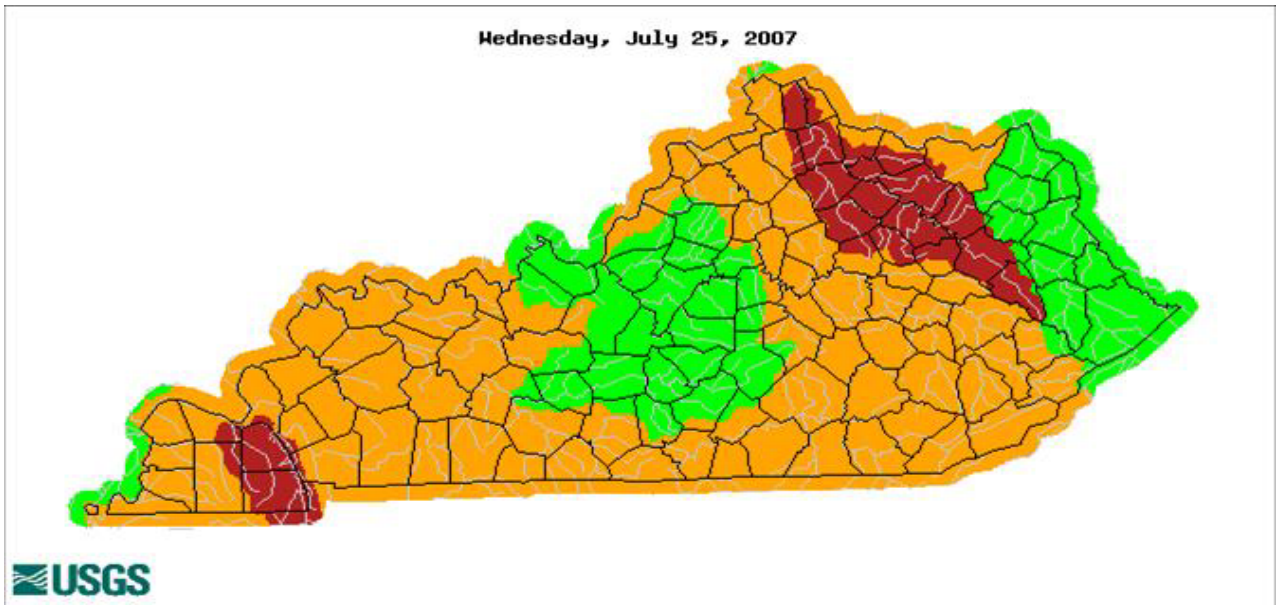
development of critical low flow conditions until more beneficial rains make it to Kentucky.

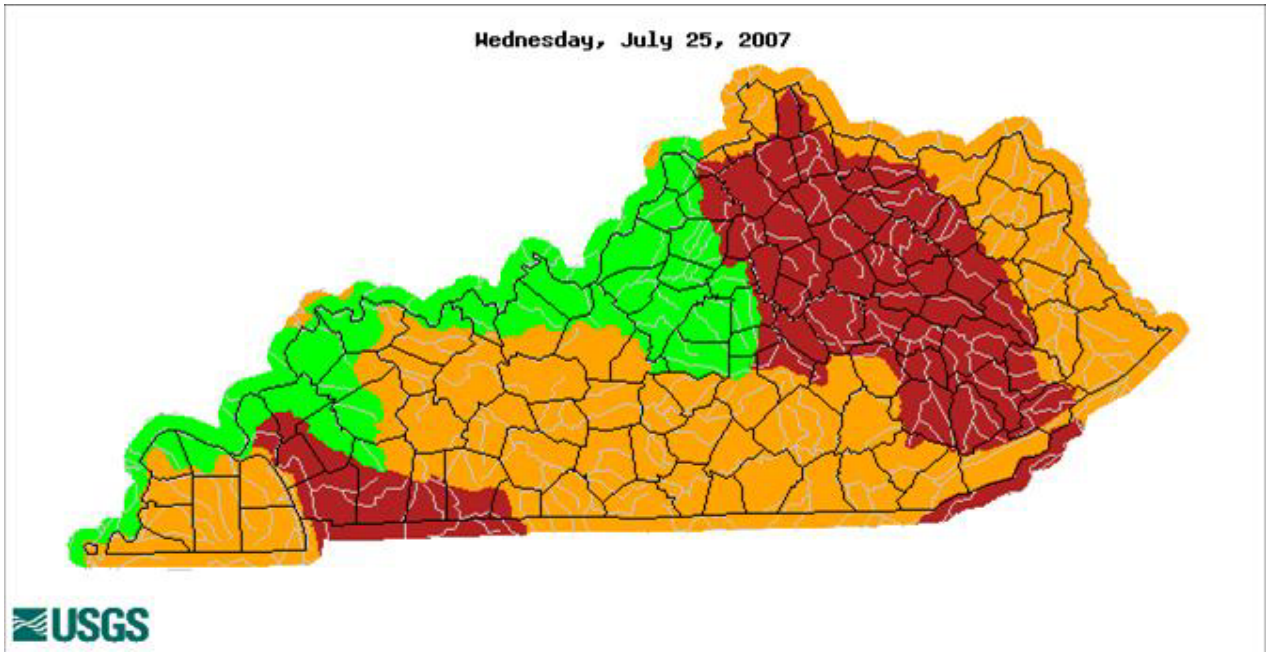
Weekly and Monthly Streamflow

For a slightly longer-term perspective of streamflow conditions across Kentucky, the United States Geological Survey computes average flows for the previous seven, 14 and 28 days. The resulting average streamflow values are categorized relative to the long-term record and assigned levels of severity based on the frequency that similar magnitudes of low flow have occurred in the past. By averaging over a period of several days to several weeks, the values on the map are more indicative of longer-term conditions than daily average or real-time streamflow measurements.

Seven-Day Average Streamflow **14-Day Average Streamflow** **28-Day Average Streamflow**







The 28-day average streamflow is still indicating that flows are significantly below normal in the Kentucky, Licking, and Lower Cumberland river basins. Elsewhere, long-term flows remain below normal except for parts of the Tradewater and Salt River basins where near-normal 28-day flows have been sustained for two consecutive weeks. The positive effects of normal rainfall in July are more apparent when looking at the 7-day and 14-day average streamflows which indicate severe hydrologic drought is retreating in all but the Licking, Lower Cumberland, and Tennessee river basins.

It is useful to remember that regional hydrologic drought can affect us even when drought conditions at home appear to be not as serious. Water supplies on rivers such as the Licking, Green or Kentucky originate from hundreds of square miles of runoff and drainage that flow from small headwater streams, to larger tributaries, to the mainstem of the river. Isolated storms that bring rain to one part of a basin may do very little to improve the overall drought status of the basin in terms of flow in the larger rivers. It is important to not confuse meteorological drought (a deficit of rainfall) or agricultural drought (soil moisture deficits) with hydrologic drought (streamflows, springs, groundwater levels). The first two types of drought are short-term and can be significantly changed by a single, soaking rainfall event. Hydrologic drought develops over a long period, has a large regional impact, and requires large regional rainfall events to return to normal conditions. Rainfall events that temporarily relieve surface drought conditions and brings greenness back to lawns may have very little impact on the drought that affects the regional drought status of water supplies.

The effects of spotty and sometimes intense summer storms on streamflows are generally short-lived and may do little for the overall hydrologic drought. Even in normal years, a majority of precipitation in the summer months either runs off into streams, evaporates or is used by plants and returned to the atmosphere, leaving only a small amount to replenish the groundwater "bank" that sustains streamflows during dry spells. The runoff component of summer storms becomes a key contributor to the overall flow in a stream. Thus, while spotty and scattered rains may not end a drought, they are still critical to maintaining adequate flows until more general and widespread relief arrives.

Lakes and Reservoirs
U.S. Army Corps of Engineers Projects

Another useful measure of the impact that drought is having on a region is the status of area lakes and reservoirs. The Division of Water monitors data from 12 projects operated by the U.S. Army Corps of Engineers (USACE) from three USACE districts: Louisville, Huntington and Nashville. These projects strive to maintain reservoirs at pool levels consistent with the operating guidelines as part of the larger mission of flood control and navigation in the Ohio and Mississippi rivers. Beginning in April, the releases from the reservoirs are managed to allow filling to the "normal summer pool elevation." Significant precipitation deficits in the basin above the reservoir can adversely affect the attainment of normal summer pool elevation. This, in turn, may result in low flows in the river below the project when releases from the reservoir are reduced to the minimum needed for water quality and aquatic habitat.

By examining the data for "current pool elevation" and "current outflow," valuable information about the status of large headwater areas above the USACE reservoirs can be obtained.

United States Army Corps of Engineer Reservoir Information
Updated July 26, 2007

July 24, 2007

Basin	Project	Current Outflow (cfs)	Normal Summer Pool Elevation (ft)	Current Pool Elevation (ft)
Little Sandy	Grayson	25.5	645	643.5
	Dewey	30.8	650	650.8
	Fishtrap	77.9	757	756.0
	Yatesville	23.8	630	629.8
Big Sandy	Paintsville	11.5	709	708.9
Licking	Cave Run	50.0	730	729.9
	Carr Creek	5.0	1027	1027.2
Kentucky	Buckhorn	40.0	782	781.9
Salt	Taylorsville	32.0	547	545.6
	Green River	49.0	675	674.6
	Nolin	267.0	515	515.4
	Barren River	53.0	552	547.6
Green	Rough River	50.0	495	494.1

As of July 26, 2007, reservoir levels remain below the normal summer pool elevation at Taylorsville Lake in Spencer County, Barren River Lake in Barren County, Rough River Lake in Breckinridge County and Grayson Lake in Carter County. Lake levels and outflows are good indicators of moderate to severe drought conditions in these areas. It is noteworthy that both Barren River and Rough River lakes have been at or near the minimum release since mid-March, further evidence that the current drought conditions have been under development for some time.

Small Lakes and Water Supply Reservoirs

Water suppliers who rely on small reservoirs are acutely aware of any deviation from normal when it comes to the amount of water in their reservoir. As with the larger USACE projects, these small reservoirs are susceptible to drought impacts that can inhibit the "refilling" or "recharge" over winter and through the spring. In addition, the daily withdrawal of water for water supply can accelerate the drop in water levels so that the ability to withstand long periods of little or no precipitation is compromised.

The Division of Water will monitor selected small water supply reservoirs when conditions indicate that water supplies may be threatened by persistent drought. As of July 26, 2007, no reports of abnormally low reservoir levels have been reported